ATTACHMENT 2
DR. FRANK CASTALDI, P.E.,
RESUME

9439733

Education

PhD Civil (Environmental) Engineering, University of Texas at Austin, Austin, TX, 1976

ME Environmental Engineering, Manhattan College, Bronx, NY, 1971

BS Civil Engineering, New Jersey Institute of Technology (formerly Newark College of Engineering), Newark, NJ, 1969

Certifications

Professional Engineer, Texas (#45047)

Golder Associates Inc. – Houston

Senior Consultant with 37 years of process engineering experience for industrial water/wastewater treatment and hazardous waste remediation system design. Professional experience includes 10 years of research and development studies in solid and aqueous hazardous waste treatment systems that resulted in four U.S. Patents and seven international patents for processes that remove petroleum hydrocarbons, cyanides, and the oxy-anions of selenium from industrial wastewaters and hazardous wastes. Dr. Castaldi's professional career has resulted in the preparation of 48 technical publications in peer reviewed journals and conference proceedings. Dr. Castaldi has conducted studies of disposal options for handling wet gas scrubber purge water from refinery fluid catalytic cracker units (FCCU) employing Belco Technologies Corporation scrubbers. He has developed process designs for installation of purge water pretreatment systems for several Gulf Coast refineries where the impact of TDS, sulfite, nitrate, and COD loads from scrubber blowdown on the refinery activated sludge process was a concern. He has developed process designs for purge water pretreatment technologies employed with SOx and NOx scrubber technologies as well as other sulfur dioxide control processes and the modifications required for upgrade of the activated sludge systems to effectively handle the blowdowns from these units. Dr. Castaldi's areas of experience include biological and physicochemical treatment of toxic organics, metals, and nutrients from petroleum refining wastewaters and K and F waste residuals from primary and secondary oil-water separations. As a Project Manager his responsibilities include technical direction and project management in water and wastewater treatment process engineering and design, engineering consultation to domestic and foreign industries on waste treatment practice, process troubleshooting, strategic planning and wastewater permitting support, and development of technical reports and proposals.

Employment History

Golder Associates Inc. – Houston, Texas
Senior Consultant and Project Manager (2011 to Present)

Brown and Caldwell – Austin, Texas
Process Engineer and Project Manager (2003 to 2011)

URS Corporation – Austin, Texas
Principal Process Engineer and Project Manager (1999 to 2003)

Radian International LLC – Austin, Texas
Principal Process Engineer (1990 to 1999)

Radian Corporation – Austin, Texas
Senior Staff Process Engineer and Group Leader (1984 to 1990)

Engineering-Science, Inc. (Parsons Corporation) – Austin, Texas
Senior Process Engineer and Project Manager (1976 to 1984)

PROJECT EXPERIENCE – SYNFUELS, OIL SHALE, AND COAL GASIFICATION WASTEWATER

Design of Treatment and Reclamation Systems for Control of Contaminants from In Situ Oil Shale Pyrolysis Operations

Developed conceptual designs of treatment systems for post-pyrolysis groundwater reclamation of a shale oil production facility for Shell Frontier Oil & Gas, Inc. The project included the development of Process Flow Diagrams (PFDs); flow and materials balances; listings of major process equipment; and chemicals, fuel, power, and water quantity estimates for the individual unit operations and/or unit processes within the groundwater treatment system. Responsibilities included the development of criteria used in the design along with process descriptions of the unit operations and/or unit processes associated with each PFD and/or flow schematic. The conventional physicochemical ex-situ water treatment technology that formed the basis of the groundwater treatment system included hydrocarbon separations, steam stripping for VOC, H2S and NH3 removal, activated carbon adsorption, sulfur recovery, catalytic oxidation for VOC and NH3 destruction, wet gas scrubbing for NOx control, metals removal, and hazardous waste management. The technologies selected provided product water acceptable for reinjection into the post-pyrolysis zone (PPZ). This treatment plant was designed to operate after heating for kerogen pyrolysis was completed. The design was based on the control of regulated constituents present in the groundwaters and a hydraulic application rate selected to rinse the PPZ within a fixed number of volumetric displacements to achieve target concentrations of the regulated water quality parameters.

Evaluation of Contaminant Control Technology for the Treatment of Wastewater from Oil Shale Chemicals Production

Conducted an evaluation of options to improve the RAS Kiviter oil shale chemicals wastewater treatment system located in the Kohtla-Järve region of Estonia. This project involved the examination of an existing biological treatment process for decontamination of wastewaters from oil shale retorting and related chemicals production at the Kiviter facility. The study which was conducted for the U.S. Agency of International Development (USAID) included a review of the feasibility of technical options to improve the wastewater treatment system, and to provide technical advice and recommendations to RAS Kiviter management on the most beneficial regional wastewater treatment scenario for the plant. A conceptual process design was developed for upgrade of the Kohtla-Järve WWTP that included improvement of the aeration basin configuration, retrofit of the existing secondary activated sludge clarifiers, and installation of granular media filtration of final sedimentation tank effluent.

Laboratory Biological Treatment Kinetic Evaluations of High- and Low-Tar Coal Gasification Process Wastewaters

Performed biological treatability studies with wastewaters from the following coal gasification processes: (1) Lurgi Dry Ash Gasifier: (2) Koppers-Totzek Gasifier; and (3) the KRW Energy Systems Gasification Process Development Unit; treatability studies were conducted as part of a characterization program to develop design and environmental data for synthetic fuels plants based on the different gasifier technologies. Studies were performed for Texas Eastern Corporation, Houston, Texas; Tennessee Valley Authority; and the Environmental Protection Agency, respectively. Studies conducted for the Tennessee Valley Authority with the biological treatment of Koppers-Totzek Gasifier wastewaters resulted in the development of an autotrophic microbial biooxidation process, which removed ammonia and thiocyanate from coal gasification process wastewaters. The technology developed during this study was applicable to the treatment of wastewaters from all non-tar forming coal gasification processes.

Anaerobic Thermophilic Treatment of High Tar Coal Gasification Processes

Performed anaerobic biological treatment studies with fixed-bed coal gasification wastewaters for EPA that were designed to assess the feasibility of using thermophilic microbial cultures to generate methane from the biodegradation of monohydric and polyhydric phenolic compounds in high strength synfuels wastewaters.

Development of Technology for Control of Wastewaters from Ash-Agglomerating Fluidized-Bed Coal Gasification Processes

Developed conceptual design options for the treatment of wastewaters from the Westinghouse ash-agglomerating fluidized-bed coal gasification process for GRI and DOE-METC. Studies included bench- and pilot-scale biological treatment of gasifier wastewaters considering the impacts of cyanide, ammonia, and hydrogen sulfide levels on mixed populations of microorganisms in continuous culture activated sludge configurations.

Evaluation of Emerging Wastewater and Solid Waste Treatment Technologies for Control of Contaminants from Coal Gasification and Oil Shale Production Processes

Performed evaluations of emerging pollution control technologies for the treatment of coal gasification and oil shale process wastewaters and solid wastes for the Argonne National Laboratory. The study assessed activated sludge/powdered activated carbon treatment for removal of organic constituents in process wastewaters from slagging, high-Btu coal gasification plants and in-situ oil shale production contaminated groundwater.

Fate and Transport of Pollutants from Non-Tar Producing Coal Gasification Processes

Managed an environmental sampling and analysis program for the Department of Energy that involved the examination of air, water, and solid wastes from non-tar producing coal gasification processes. The program emphasized the evaluation of environmental data for the purpose of developing waste control systems for the synfuels industry with respect to commercial non-tar producing gasifiers.

PROJECT EXPERIENCE – INDUSTRIAL WASTE TREATMENT PROCESS DEVELOPMENT

Process for Removal of Selenium from FGD Purge Water

Developed a chemical reduction and co-precipitation process for Radian International LLC that achieves the removal of the oxy-anions of selenium (i.e., selenite and selenate) from limestone-based flue gas desulfurization (FGD) scrubber purge waters produced by coal-fired electric power utilities. The process reduces the selenate and selenite anions to elemental selenium after overcoming the inhibiting effects of selenium-thionate complexes and sulfur-nitrogen compounds (e.g., hydroxylamine disulfonate). It is capable of achieving 95% removal of selenium from FGD scrubber purge waters that also contain high concentrations of total dissolved solids (TDS) comprised mainly of calcium, magnesium, sulfate, and chloride.

Slurry Bioremediation of Petroleum and Petrochemical Production Hazardous Wastes

Developed a slurry bioremediation process for Radian Corporation that treats hazardous waste constituents in tarry and oily sludges and associated soils from petroleum and petrochemical production processes. This technology, called the Radian Bio-Slurry Reaction Process (BSRP), microbially degrades RCRA hazardous waste constituents in a series of high solids slurry bioreactors that achieve both waste dissolution and biooxidation of toxic organic compounds.

Cyanide Removal from Industrial Wastewater

Developed a chemical/biological wastewater treatment process for Radian Corporation that removes free cyanide from metal plating, chemical production, and mining industry wastewaters. This technology, called the Radian Cyanide Conversion Process (CNC process), chemically converts free cyanide to a readily biodegradable form and achieves complete degradation of the cyanide through the mechanism of autotrophic biooxidation.

PROJECT EXPERIENCE – REMEDIAL SYSTEM PROCESS DESIGN - UNITED STATES MILITARY

Remedial Process Optimization Evaluation

Performed the remedial process optimization evaluation of the Area H pump and treat (P&T) system at the Naval Air Engineering Station, Lakehurst, NJ for the Air Force Center for Engineering and the Environment (AFCEE). The environmental restoration program optimization (ERP-O) involved the review of the remedial treatments installed at the launch end of the test tracks and down gradient of the plume. Although recovered groundwater met the Federal MCLs for the constituents of concern, the recovered groundwater periodically exceeded the PQLs for benzene, ethylbenzene, xylenes, naphthalene, cis-1,2-dichloroethene, and vinyl chloride. The evaluation indicated that the approximate cost of treating a pound of total VOCs exceeds $8,000, while the cost per pound of treating a specific priority constituent (e.g., benzene) to the PQL was greater than $100,000 per pound of contaminant. It was concluded that the costs of operating the existing pump and treat system may now exceed the benefit. The evidence suggests that the pump and treat system is no longer cost effective and monitored natural attenuation (MNA) and/or enhanced natural attenuation (ENA) should be considered potential long-term remedies. The study found that geochemical parameters should be added to the groundwater monitoring program to better understand the natural processes that are occurring or could potentially be enhanced in the subsurface. Studies of the plume dynamics and the demonstration of protectiveness for site-specific receptors are needed to establish MNA as an appropriate remedy.

Air Force Base Groundwater Pump and Treat Systems Performance Evaluations

Managed a study for AFCEE that generated data related to active versus natural mass removal rates for 20 large Pump and Treat (P&T) systems. The study was designed to inform decision makers of opportunities to substantially improve mass removal cost efficiency. The intent was to identify strategies for improved efficiencies by taking maximum advantage of natural attenuation mechanisms and/or by focusing operations on more productive extraction wells. The focus of the assessments was sites with groundwater contaminated with chemicals where P&T technology was the selected remedy, either interim or final. A representative site was one contaminated with dissolved chlorinated aliphatic compounds and/or petroleum hydrocarbons where a P&T system was expected to operate for many decades because of diffusion- and/or desorption-inhibited mass transfer limitations. Typical chlorinated aliphatics that were targeted in this study included trichloroethene (TCE), tetrachloroethene (PCE), 1,1-dichloroethene (1,1-DCE), 1,2-dichloroethene (1,2-DCE), carbon tetrachloride, chloroform, 1,1,1-trichloroethane, and monochloroethene (vinyl chloride). Assessment summaries for each candidate P&T system were prepared for the sites and submitted to the Air Force. The summaries included recommendations for system changes to achieve improved mass removal efficiency. Activities included the acquisition of P&T system performance data; data screening, computation, and review for quality control/assurance; performance of contaminant mass removal assessments, including estimates of the P&T system extraction performance and natural attenuation rates based on mass balance methodology; and the production of specific site reports for client review and comment.

Pre-Treatment System for Aircraft Paint Stripping Operations

Conducted wastewater characterizations and bench-scale treatability testing and developed a process design for a pre-treatment system to remove solvents from rinse waters generated during aircraft paint stripping and re-painting operations at Building 220 at Hill Air Force Base, Utah. The client was the Army Corps of Engineers. The study was conducted to evaluate the technical feasibility and cost of removing toxic organics such as methylene chloride, toluene, 1,1,1-trichloroethane, 1,1-dichloroethylene, naphthalene, and bis (2-ethyl hexyl) phthalate from wastewaters generated at Building 220. A preliminary process design was developed for a pre-treatment system that employed chemical coagulation/flocculation/sedimentation for removal of colloidal particles including phthalates and metals. The pre-treatment system was to also employ either steam or air stripping to achieve removals of methylene chloride and other chlorinated solvents. However, the pre-treatment system was not implemented because Building 220 would abandon the use of chlorinated solvents for paint stripping and begin employing bead-blasting as the primary means of removing paint from military aircraft.

Design of End-of-Pipe Toxic Organic Treatment System

This project included a base-wide wastewater characterization study, and bench- and pilot-scale treatability studies, and the development of a process design for an end-of-pipe toxic organic removal treatment system at the Hill Air Force Base, Utah. The client was the Army Corps of Engineers. The study assessed the treatment requirements for removal of toxic organics from wastewaters generated during the stripping and painting of military aircraft and aircraft parts throughout the Hill AFB complex. The study resulted in the design and installation of end-of-pipe wastewater treatment facilities that included oil sorption, air stripping and activated carbon adsorption. This toxic organic removal system was incorporated as a tertiary treatment for the existing Base Industrial Wastewater Treatment Plant (IWTP). The concept design for the treatment plant was validated during a three month pilot test at the base. Responsible for the development of process flow diagrams (PFDs), piping and instrumentation diagrams (P&IDs), flow and mass balance calculations for the treatment system. The detail design drawings and specifications for the plant were produced by Case, Lowe, and Hart, Consulting Engineers, Inc., Ogden, Utah. The treatment system was designed to remove a combination of chlorinated solvents including methylene chloride, tetrachloroethylene, trichloroethylene, and aromatic hydrocarbons. Also present in the wastewaters were phenolics, naphthalene, and phthalates. The treatment plant was constructed in late 1987. Developed the operations manuals and managed a team that provided start-up services and training to Base personnel until early 1988. This start-up effort also included effluent testing to validate that the toxic organic treatment system design met all permit limitations for the regulated organic pollutants in the Hill AFB wastewater. Effluents from the Base IWTP were discharged to the Publicly Owned Treatment Works (POTW) located in North Davis, Utah.

Design of Groundwater Recovery and Treatment for Chemical Waste Disposal System

This project was focused on the development and design of a groundwater treatment and solvent recovery system at the Chemical Disposal Pit 3, Hill Air Force Base, Utah. The project was conducted jointly for Hill AFB and the Brooks AFB, Texas. The pre-design evaluations included a remedial investigation and feasibility study at the site of past hazardous waste disposal on the eastern boundary of the Hill AFB. Chemical Disposal Pit 3 was used for the storage of spent degreasers and paint stripping solvents. Large volumes of chlorinated and non-chlorinated solvents were disposed of at this site and were subsequently found to have contaminated the shallow underlying soils and groundwater. The hazardous chemicals known to exist at the site included methylene chloride, trichloroethylene, and toluene. The project involved the selection and evaluation of alternative groundwater treatment technologies for removal of dense non aqueous phase liquids (DNAPLs) from recovered groundwater, laboratory testing of the candidate technologies, and the development of conceptual process designs and preliminary costs for the selected treatment approaches. The study examined air and steam stripping, activated carbon adsorption, and multiple-oxidant chemical oxidation methods for treatment of the DNAPLs. This evaluation resulted in the selection of a steam stripping process for groundwater treatment that was preceded by a tank-based batch emulsion-breaking and decanting system. Activities included technology evaluations, treatability testing, and the process design of each unit operation of the groundwater treatment system. The Chemical Disposal Pit 3 groundwater treatment facility was installed in late 1995. The treatment facility continues to recover DNAPLs from the groundwaters within the area of the disposal pit. In subsequent years the pre-treatment system was used as theSource Recovery System (SRS) for Operable Unit (OU) 2.

Surfactant Enhanced Aquifer Remediation Demonstration

This project which was conducted jointly with Duke Engineering & Services (DE&S) and the University of Texas at Austin involved a demonstration level evaluation of surfactant enhanced aquifer remediation (SEAR) technology at the Operable Unit 2 (OU 2) site, Hill Air Force Base, Utah. A pilot-scale surfactant flood was conducted inside a containment wall at the OU 2 Site to remediate an area contaminated with DNAPLs. The primary groundwater contaminant targeted by the SEAR was trichloroethylene (TCE). The SEAR wastewaters generated during the surfactant flood were treated at the OU 2 Source Recovery System (SRS). The SRS, which included gravity separation and steam stripping, served to pre-treat the SEAR wastewaters before discharge to the Base IWTP. Responsibilities included process modeling of the SRS steam stripper to identify the appropriate system operating conditions necessary to achieve effective treatment of the SEAR wastewaters. The modeling indicated that the steam stripper would experience both excessive foaming and scale formation unless temperature and pH were strictly controlled during treatment. Retrofits on the steam stripper included the installation of a new rectifying column and controls for maintenance of unit temperature and pH within prescribed set points. Additional studies involving technology screening of treatment methods for reducing the foam generation and stability of the SEAR wastewater. These evaluations examined treatment technologies such as micellar enhanced ultrafiltration, foam fractionation, chemical precipitation, and acid/alkaline hydrolysis. Testing to select the most appropriate technology was not conducted at that time because of budgetary constraints.

PROJECT EXPERIENCE – BIOLOGICAL TREATMENT OF INDUSTRIAL WASTEWATERS

Refinery Wastewater Nitrate Removal

Prepared a white paper for the Chevron Energy Technology Company (ETC) on the state-of-the-art of biological nitrate removal processes and systems that have potential application to the treatment of petroleum refinery wastewaters. The review of literature for biological denitrification in petroleum refining wastewater treatment applications concluded that biological denitrification provides a viable solution to the problem for nitrate-nitrogen control because this technology can be incorporated into the existing activated sludge process flow scheme with the addition of an anoxic zone either prior to the existing aerobic bioreactor (single-sludge design), a separate anoxic zone between the existing aerobic bioreactor and clarifier (single-sludge design) or as a tertiary anoxic bioreactor stage after the aerobic bioreactor (two-sludge design). The advantages of a pre-denitrification design are that it reduces the quantity of exogenous carbon required, replenishes alkalinity consumed during the nitrification reactions, reduces aeration requirements, and introduces a selector effect to potentially control viscous bulking effects in the final clarifier. The primary disadvantage of a pre-denitrification design is that it requires an internal effluent recycle system that involves pumping large volumes of effluent from the aerobic stage back to the anoxic stage of the treatment system. Greenhouse gas emissions were found to be a concern with biological denitrification processes. The study concluded that the type and carbon chain length of the exogenous carbon source employed in the denitrification process was responsible for the type and amount of greenhouse gas emitted. Spent sulfidic caustic waste was determined to be a useful source of electron donors for autotrophic denitrification when injected into the anoxic zones of a biological nitrogen removal process. Denitrification reactor systems that were found to be appropriate for use in petroleum refining wastewater treatment applications were the SBR, USBR, the closed RBC, the MBBR, the MBR, and variations of the conventional attached growth denitrification biofilters. These biological reactor types represent commercial technology, although they are currently not used in refineries to achieve biological denitrification. In particular, SBR denitrification technology may be an effective pretreatment system for removal of the high nitrate-nitrogen and sulfite concentrations found in NOx control WGS purge water.

Autotrophic Biooxidation of Carbon Black Production Wastewaters

Designed a chemical/biological process for treatment of combined scrubber and cooling tower blowdowns from the Engineered Carbons, Inc. (Ameripol Synpol Corporation), carbon black facility in Baytown, Texas. The process consisted of a chemical conversion of free cyanide to thiocyanate and subsequent biodegradation of the sulfur-nitrogen groups to sulfates and nitrates through the mechanism of autotrophic aerobic activated sludge treatment.

Biotreatment of Process, Utility, and Process Area Stormwater

Performed fed-batch reactor biological treatability testing on wastewaters collected from process, utility, and process area stormwater drainage for the Baytown, TX operations of Texas Petrochemicals, LP. The purpose of the biological treatment screening test was to upgrade the effluents from a stripper effluent hold up tank to effectively reduce the incidence of elevated BOD and TOC that discharges from an internal outfall to the final discharge outfall at this facility. The major organics in the process wastewater were identified as IPA, n-propanol, and methanol, which were measured in samples collected from process distillates. These elevated BOD/TOC discharges had resulted in TPDES compliance problems at the Baytown Operations. Wastewater sampling of process streams indicated the presence of high concentrations of primary and secondary alcohols that originated with the feed stock. Existing process wastewater treatment at the facility consisted of only air stripping, which was ineffective for removal of the major wastewater constituents. The noncompliance issue required that an effluent treatment system for the alcohols and other organics present in the process wastewater be evaluated on the bench-scale employing batch biological reactor technology. A dual fixed-film and suspended biomass microbial process was recommended for treatment of the facility wastewater. A temporary system included off-specification stripper effluent storage to provide emergency holding capacity for treated effluents that exceeded the effluent limitations requirements at the internal process outfall. Ultimately, the compliance problem was resolved by instituting a system of feed stock quality control and removing the permit requirements at the internal outfall.

Thermophilic SBR Treatment of Oily Wastewaters from LNG Processing

Performed thermophilic (greater than 55°C) aerobic degradation studies on wastewaters from liquefied natural gas processing using sequencing batch reactors (SBRs) for the Ras Laffan LNG Company, Limited, Qatar. The wastewater streams treated in the biological treatment process included chemical sewer wastewater from gas processing, partially treated wastewaters from oily water sewers, and other production-related waste streams. The studies resulted in the development of a thermophilic SBR process for LNG wastewater treatment.

PAC Treatment of Refinery Wastewater

Developed a powdered activated carbon (PAC) - activated sludge process as a modification to an existing biological treatment system at the Marathon Ashland Petroleum, LLC refinery in Robinson, Illinois. This process was designed to remove whole effluent toxicity from the Robinson Refinery wastewater treatment system effluents.

Aerobic and Anaerobic SBR Treatment of Isopropyl Alcohol Wastewater

Performed biological treatability studies with sequencing batch reactors (SBRs) for Baroid Drilling Fluids, Inc. on wastewaters generated during the manufacture of oil field drilling fluid products. The study examined the feasibility of Isopropyl Alcohol (IPA) removal using fed batch systems at either mesophilic (less than 35°C) or thermophilic (greater than 55°C) temperatures for both anaerobic and aerobic conditions. A continuous fed STR anaerobic mesophilic activated sludge process was selected as the most cost-effective treatment for the IPA wastewater.

Thermophilic Aerobic Digestion of Refinery Activated Sludges

Performed autothermal thermophilic aerobic digestion studies using biological sludges from the Marathon Oil Company, activated sludge process at the Robinson, Illinois Refinery. These studies demonstrated that refinery waste activated sludges can be digested using ATAD technology.

Aerobic Treatment of Combined Pesticide and Herbicide Production Wastewaters

Performed biodegradation studies with combined wastewaters from pesticide and herbicide production and dyes and pigments manufacture for Sudarshan Chemical Industries Limited, Pune, India. The biological treatability study provided data for the design of a full-scale activated sludge process that successfully treated the chemical manufacturing facility wastewater to the state-mandated effluent quality limits.

Aerobic Treatment of Propylene Oxide Surfactant Wastewaters

Conducted biodegradation studies for an industrial client with wastewaters containing a variety of propylene oxide surfactants. The purpose of the biodegradation testing was to assess the extent to which microorganisms can alter or decompose the surfactants in order to assess the fate of the material in the environment.

Aerobic Treatment of Herbicide Production Wastewater

Conducted biological treatment studies with wastewaters from the production of herbicides for PPG Industries, Inc. Bench-scale biological treatment studies were conducted on combined herbicide process wastewater and municipal sewage to evaluate the feasibility of achieving biological nitrification and control of filamentous growth in an organic overload situation on a conventional municipal activated sludge system.

Aerobic Treatment of Ethylene and Ethylene Oxide Production Wastewaters

Performed in-plant wastewater survey and biological treatability study to develop design criteria for a new activated sludge process treating ethylene and ethylene oxide production wastewaters for the Northern Petrochemical Company in Morris, IL. The study resulted in the design of an activated sludge process that successfully treated the chemical manufacturing facility wastewater to the state-mandated effluent quality limits.

PROJECT EXPERIENCE – INDUSTRIAL WASTEWATER TREATMENT STUDIES AND CONCEPTUAL DESIGNS

Polysilicon Manufacture Wastewater Treatment

Performed the design of pre-treatment systems for process and utility wastewaters produced during the manufacture of polysilicon at the Hoku Materials, Inc., Pocatello, ID Plant. The wastewaters at this facility include reverse osmosis concentrates from deionized water production; off-gas wet scrubber blowdown; etch rinse water, polysilicon reactor wash water, and HCl production wastewater; blowdowns from boilers and facility cooling towers; and wastewater from spent caustic scrubber purge water collection and emergency vent quench operations. The resultant wastewater was high in dissolved salts, calcium and magnesium hardness, and silicates. The wastewater disposal system was designed as a zero liquid discharge (ZLD) operation employing an evaporator-crystallizer system where the condensates from the evaporator are recycled as makeup water to the cooling towers and the dried salts from the crystallizer are landfilled off-site. Although hardness components alone didn't present a problem for the operation of the evaporator, the high levels of silica in the wastewater would result in divalent-silicate scales that adversely impact the operation of the evaporator-crystallizer system. The high scale potential of these wastewaters made it necessary to provide pre-treatment to lower the silica to levels that would not form silicate scales on heat transfer surfaces. The principle objective of the pre-treatment system was to remove silica from the wastewater. The pre-treatment system was designed as a batch precipitation-neutralization process incorporating a thickening-dewatering unit operation for sludge management. The pre-treatment system lowered the scale potential of the wastewater to where the evaporator-crystallizer performed without excessive system down-time for scale removal and the need for chemical additives to achieve corrosion control.

Evaluation of Sodium Silicate Corrosion Control Technology

Performed an evaluation of the use of soluble sodium silicates to inhibit corrosion of metal surfaces within the cooling system at the Microsoft Northlake Data Center in Chicago, IL. The study evaluated the properties and effectiveness of sodium silicate films applied for corrosion control of metal surfaces. Source waters that were free of silica provided a manageable test of silica corrosion control chemistry because sodium silicates were added in a controlled manner. During the study, all forms of polyvalent cations including trivalent cations like aluminum were monitored closely in the cooling system. The pH of the cooling water was controlled at above pH 9.6. The cooling tower operating conditions at the Northlake Facility was consistently maintained at a total hardness in the condenser water at less than 30 mg/L as CaCO3. This required that the plant water softening system (WSS) achieve make up water hardness levels that were consistently less than 0.3 mg/L. The successful operation of the WSS was critical to the successful operation of the silicate chemistry program for cooling system scale and corrosion control. To inhibit corrosion of metal surfaces, the cooling system accumulated silica such that water soluble silica levels in the condenser water achieved a concentration greater than 200 mg/L based on the information provided in the vendor patents. The desired concentration of silica was achieved both by operation at high COC and with the addition of sodium silicates to the cooling tower make up water. The Northlake Facility cooling tower was operated as a zero blowdown system where losses from the towers were solely through evaporation and drift. Projections of monthly water consumption for the Data Center (i.e., full build out) indicated that a zero blowdown system may be achieved at 50 COC, but it also was probable that the towers would need to operate at higher COCs than 50 to avoid all possibility of cooling tower blowdown from the system during periods of higher cooling water demand. Cooling towers operated at TDS concentrations greater than 35,000 mg/L and pH values greater than 9.6 appeared not to experience biofouling problems when on the silicate chemistry program. Microbial control was achieved with the silicate chemistry without supplemental biocide addition. Biofouling of heat transfer surfaces was not apparent at high TDS and during operation at pH levels greater than pH 10.

Engineering Evaluation of MPPE Technology Applied to Refinery Wastewater
Gallup, New Mexico, USA

Performed an evaluation of the macro-porous polymer extraction (MPPE) technology applied to the treatment of petroleum refinery wastewater for a confidential petroleum refinery client. The MPPE technology was sized for benzene removal and to achieve pure hydrocarbon phase recovery. The study indicated that the turndown ratio could be adjusted from less than 20% to more than 100% of the installed flow capacity of the unit. The system adjusted to changing flow and target constituent concentration levels while maintaining consistent effluent quality. The focus of the study was to examine conditions optimum for immobilized extraction fluid removal of constituents that have partition coefficients with a high affinity for the extraction liquid used in the MPPE technology. A cycle time of one-hour extraction and one hour regeneration was evaluated during the study. The study concluded that the off gases from the water and condensate separation stage required control because of the relatively high vapor pressure of the constituents of concern. To minimize emissions of vaporized organic constituents, a vapor-phase activated carbon system on the off gas vent line was employed.

WAC-SAC Ion Exchange System Evaluation
Quincy, Washington, USA

Evaluated the technical and economic feasibility of replacing strong acid cation (SAC) exchange resins with weak acid cation (WAC) exchange resins to achieve hardness removal from raw waters used for cooling tower makeup for Microsoft Corporation. The WAC exchange resin preferentially removed the divalent cations over the monovalent cations. The monovalent cations (i.e., sodium) were also taken up on the WAC resin, but were displaced by each new divalent cation (e.g., calcium) that was present in the makeup water. The WAC resins performed as partial demineralizers (i.e., sodium was not removed). A SAC resin bed positioned downstream of the WAC resin was used to achieve complete cation removal. The primary advantage of this system over the use of the SAC alone was less acid to regenerate the resin beds (i.e., WAC-SAC) than that required to regenerate a single SAC resin bed. The frequency of regeneration also was less. When the alkalinity (as equivalents) exceeded the calcium and magnesium hardness, sodium bicarbonate was present and a reduction in WAC resin capacity occurred mainly because of the sodium ions (not the bicarbonates). Calcium and magnesium removal for safe operation of silica-based corrosion control was impacted by the amount of sodium present in the raw water. The critical condition was the amount of pass-through of residual magnesium hardness with respect to silica/silicates and its potential to form hard scales in the cooling system.

Neutralization System Solids Management Alternatives

Performed a design evaluation of pH neutralization system solids management practices for the LyondellBasell Industries (LBI) Tuscola, IL facility. The neutralization system was generating solids during pH adjustment of landfill area leachate. These solids were carried with the treated leachate to deep well injection. The sediment loading observed during the leachate treatment indicated the need for periodic cleanouts to prevent impairing the existing deep well waste disposal system. A modification of the current leachate pH neutralization system was evaluated that would permit the management of suspended solids in a manner that would not hinder the operation of the existing deep well system. To accomplish this objective it was necessary to better understand the chemistry of the leachate and the precipitants that occur during neutralization. The study included water quality sampling for major anions and cations, which allowed the development of an ion balance that was used to predict the quantity and quality of the precipitants formed during pH neutralization. The project evaluated solids generation and heavy metals removal during neutralization using magnesium hydroxide and compared this reagent with the current sodium hydroxide neutralization system. Evaluations of settling rates and sludge compaction properties using both magnesium hydroxide and sodium hydroxide were conducted. These data were used to develop process designs and costs for separate sedimentation-thickening and dewatering facilities that could be integrated with the current and/or modified pH neutralization system.

Refinery Oily Solids Centrifuge Dewatering Assessment

Performed an assessment of petroleum refinery oily solids centrifuge dewatering technologies for the Flint Hills Resources (FHR), Pine Bend, MI Refinery. The project involved the evaluation of emulsion breaking of API separator oily sludges and dissolved gas flotation oily float using centrifugation. The project was an engineering evaluation of current operating conditions and also included a comparison of two phase vs. three phase centrifuge decanting technologies. The study concluded that two-phase centrifuges were unable to break the emulsions that result from refinery processes and that these emulsions generally were returned to the API separator with the centrate. Their accumulation in the wastewater treatment system had deteriorative impacts on the performance of the refinery wastewater treatment process. Over the history of operation of the primary sludge treatment system there have been occasions when the centrate contained 40,000 mg/L TDS and 4 wt % oil. A technical memorandum was prepared on the state of practice of centrifuge dewatering of DGF float and other similar oily wastes that addressed industry best practice; current refinery operations; data collection gaps; and typical processing steps for centrifuge dewatering of primary sludges at petroleum refineries. The study evaluated current refinery performance data to assess whether the facility was collecting sufficient data to adequately operate their primary sludge treatment process and produce a dewatered cake of high solids concentration and low moisture for disposal.

Airport Stormwater Runoff and Deicing Fluid Management Performance Evaluation

Performed inspections and operability reviews of existing stormwater control environmental stations at the George Bush Intercontinental Airport, Houston, TX. The airport environmental stations were designed to prevent petroleum hydrocarbons and deicing chemicals from entering the storm sewers and ultimately, the receiving waters. These stations consisted of an oil-water separator (OWS), one or more oil and/or glycol wash water storage tanks, lift stations and associated appurtenances, valve vaults, and flow control structures including submersible pump lift stations, peristaltic pump systems for transfer of accumulated oil, and drainage submersible pumps. The inspections were performed pursuant to the standard quarterly evaluation of Best Management Practices (BMP) for stormwater management, and the recommended corrective actions were designed to bring the environmental stations to a level of operability consistent with the original contract drawings for the stations evaluated. The study concluded that the OWS units needed upgrade of their internal inlet diffusion baffles, primary (i.e., parallel plate) coalescers, secondary (i.e., fibrous media) coalescers, and inlet/outlet arrangements consistent with conventional design practices for gravity OWS units. A first flush evaluation indicated that the existing OWS units were designed primarily for management of storms that are of long duration and low rainfall intensity. Supporting information identifying the specific stormwater treatment station component requiring replacement and/or repair and the associated costs was developed. Budgetary costs for replacement and/or repair included the costs associated with supplemental piping, electrical and instrumentation in addition to engineering design and construction supervision for upgrade of the on-site treatment systems.

Primary and Secondary Oil-Water Separator Design and Cost Evaluations for Petroleum Refineries

Performed process engineering designs for primary and secondary oil-water treatment of refinery wastewaters for the following clients: ConocoPhillips Wood River, IL Refinery; Chevron Beaumont, TX Oil Storage Terminal; Chevron Richmond, CA Refinery; Valero Corpus Christi, TX Refinery; and the Valero Houston, TX Refinery. These projects included process selection, engineering design calculations, and the development of flow and mass balances, process flow diagrams, piping and instrumentation diagrams, equipment specifications, and costs.

Water Treatment System Design for Process and Utility Water Needs at Chemical Production and Waste-to-Energy Facilities

Performed water treatment system designs for the upgrade of existing chemical coagulation, filtration, softening and demineralization treatments that supply water for process and boiler water feed systems at the ISP Port Neches, TX Elastomer Production Plant. Performed a preliminary process design and cost evaluation for a grass-root boiler water treatment system for the Kauai, HI Biomass to Energy Project. Both projects included process selection, engineering design calculations, and the development of flow and mass balances, process flow diagrams, piping and instrumentation diagrams, equipment specifications, and costs.

Evaluation of Silica-based Corrosion and Scale Control Technology

Performed an assessment of high concentration silica corrosion control technology as applied to compression cycle air-conditioning systems similar to those employed in network data center applications. The project was conducted for GFS Data Center Research and Engineering Department of Microsoft. The evaluation was a review of topics related to the use of soluble sodium silicates to inhibit corrosion of metal surfaces. The topics addressed were (1) metal corrosion and inhibition; (2) characterization of silicate species in solution; (3) known mechanisms of silicate film formation; (4) review of selected experimental studies; and (5) results of metal surface analysis where sodium silicate corrosion control was employed. Some of the critical issues that were examined in the study included (1) the effect on iron and manganese sequestration; (2) the effectiveness of silicate treatment with and without preexisting corrosion products; (3) the effect of water quality on silicate film formation; and the (4) pH effect of silicate treatment. The study concluded that sodium silicate as a corrosion inhibitor has had mixed success. There have been both positive and negative experiences with sodium silicate chemistry applied to corrosion control. It was concluded that silicate films will form on metal surfaces and help to inhibit corrosion, but sodium silicate treatment must be conducted at pH values above 9.6 to be effective.

Cooling Water System Evaluation for Corrosion and Scale Control

Performed an evaluation of cooling water system corrosion and scale control options for application to high silica water systems for Microsoft at their Columbia, Quincy, WA Data Center. The study involved evaluations of chemical additives for control of silica induced scale. The project also included an evaluation of zero liquid discharge (ZLD) and related system designs for evaporative cooling systems operated under strict dissolved solids discharge limitations.

Design of Carbon Dioxide Neutralization System for Scale Control

Performed a process design of a carbon dioxide neutralization system for the Owens Corning, Napa, CA custom stone manufacturing facility. The study evaluated state-of-the-art carbon dioxide neutralization systems and gas-liquid dissolution technology with associated instrumentation for process control. The project included process selection, engineering design calculations, and the development of flow and mass balances, process flow diagrams, equipment specifications, and costs.

Separation and Treatment of Desalter Mudwash Wastewater from Synbit Crude Refining

Developed a process design for a desalter mudwash solids separation facility associated with the refinery expansion project at the ConocoPhillips Wood River Refinery, Roxanna, IL The mudwash treatment system is integrated with improvements to wastewater treatment that result from the processing of a 50/50 blend of Athabasca oil sands bitumen and synthetic oil (synbit crude). Synbit crude processed through the desalters of two distillation units result in an increase in the mudwash frequency and the amount of solids that need to be removed from the desalters on a regular basis. The design employs two-phase centrifuges followed by sequenced-batch centrate treatment tanks that provide contact time for emulsion breaking for effective oil-water separation. Centrifuge cake and centrate oil and water quality was predicted from laboratory treatability testing and pilot plant data. The assumed cake quality is 30 to 35 wt % solids and 15 to 20 wt % oil. Cake water content is 45 to 50 wt % brine water. Design documents included PFDs, heat and mass balances, equipment lists, and design specifications.

Oil Removal from Crude Storage Terminal Wastewater

Performed an evaluation of existing gravity, differential-type oil-water separation systems at the Chevron Oil Storage Terminal in Beaumont, Texas. The study developed conceptual process designs for installation of primary and secondary oil recovery systems including API and CPI type gravity oil-water separators, dissolved nitrogen gas and induced nitrogen gas flotation oil-water separators, and the associated slop oil handling facilities.

Removal of Whole Effluent Toxicity from Refinery Wastewater

Conducted an evaluation of treatment technologies for removal of whole effluent toxicity from refinery and chemical process wastewaters at the ConocoPhillips Refinery and NGL Center in Borger, Texas. The project included bench- and pilot-scale testing of membrane treatment processes (microfiltration and ultrafiltration) and liquid-phase activated carbon adsorption. Granular and powdered activated carbon (PAC) technologies where evaluated during the study for treatment effectiveness and cost. Pilot tests were performed on Borger wastewaters using PAC activated sludge (AS) treatment technology and a process design was developed for modification of the current wastewater treatment system to a PAC-AS process that would treat 6.3 MGD of refinery wastewater.

Removal of Copper and Zinc from Natural Gas Fractionation Wastewater

Conducted an evaluation of metals removal technologies for removal of copper and zinc from natural gas fractionation plant wastewaters and cooling tower blowdowns at the Dynegy Midstream Services, L.P. complex in Mont Belvieu, Texas. The project included bench-scale testing of ligand adsorption, ultrafiltration, and chemical coagulation as candidate metals removal technologies. Pilot-scale test data were developed for the Octolig® ligand adsorption process and these data were used to develop a process design, flow and mass balances, and piping and instrumentation diagrams for a metals removal system that treats 280 gpm of wastewater.

Treatment of Wastewaters from Fire Training Field Operations

Provided design peer review of a wastewater treatment plant for treatment of contaminated firewater from the Brayton Fire Training Field, Texas A&M University. Participated in the identification and evaluation of wastewater treatment alternatives. Consulted on the development of a sample collection and analysis plan to evaluate existing conditions, reviewed the basis of design, and performed calculations in support of the design of the wastewater treatment system upgrade.

Treatment of Oily Produced Water from Oil Exploration and Production Operations

Conducted an evaluation of wastewater treatment and water reuse options for disposal of produced waters from oil production in the Caspian Sea for the Azerbaijan International Oil Company, a joint-venture between British Petroleum and the State Oil Company of the Azerbaijan Republic. The study also examined the technical and economic feasibility of produced water reuse as irrigation water. Wastewater treatment technologies evaluated during the study included primary and secondary oil-water separations, biooxidation processes, membrane processes, ion exchange, immobilized ligand chelation, macro porous polymer extraction, advanced oxidation processes, natural freeze-thaw/evaporation, and phytoremediation using salt tolerant reed beds.

Treatment of FCCU Wet Gas Scrubber Purge Water

Developed a process for the treatment of FCCU wet gas scrubber purge water for Motiva Enterprises LLC, Port Arthur, Texas. In this process, the scrubber purge water is treated in an aerated concrete lined saline pond that provides both sulfite oxidation and catalyst fines separation. The process serves as a pre-treatment prior to blending the purge water with other waste streams from petroleum refining operations.

Removal of Selenium from FGD Purge Water

Developed the process design for a proprietary selenium removal technology applied to the treatment of flue gas desulfurization (FGD) process scrubber purge waters. The technology removes selenium from FGD process purge water to less than 70 parts-per-billion from an initial concentration of greater than 4.0 mg/L. The treatment facility was installed at the Seminole Generating Station (Palatka) of the Seminole Electric Cooperative, Incorporated, Tampa, Florida.

Removal of Organo-Metal Complexes from Solar Cell Production Wastewaters

Performed an evaluation of wastewater pollution control technologies for the solar cell manufacturing facility of BP Solar Inc. at Fairfield, CA. The project included the selection, design, and implementation of a chelating ion exchange technology for removal of organo-metal complexes from process wastewaters to low parts-per-billion levels.

Oil Removal from Railyard Wastewater

Performed an evaluation of existing gravity, differential-type oil-water separation systems at the Clovis, New Mexico rail yard of the Burlington Northern and Santa Fe Railway Company. The study also developed conceptual process designs for installation of secondary oil recovery systems including dissolved air flotation oil-water separation.

Control of Filamentous Bulking during Chemical Production Wastewater Treatment

Conducted a study of options for control of activated sludge bulking and foaming and associated suspended solids carry over from the biological treatment process at the Hoechst Celanese, Narrows, Virginia cellulose acetate manufacturing facility. This facility uses selector reactor technology to control filamentous microorganism bulking in a Biohoch® reactor. The study resulted in recommendations for process improvement that included the implementation of step-feed for viscous bulking control and a reduction in the period of endogenous respiration in the last reaction stage; management of nutrient addition to control denitrification; improved equalization to moderate the organic loading on the biological process; and greater control of solids residence time through more effective sludge management.

Removal of Organic Acids from FGD Purge Water

Developed a aerobic-mesophilic biological treatment process to remove organic acids in flue gas desulfurization (FGD) purge waters from the Schahfer Generating Station of the Northern Indiana Public Services Company (NIPSCO). The process employed continuous-culture suspended growth aerated lagoon technology without biomass recycle.

Specialty Chemicals Production Wastewater Treatment

Performed a wastewater characterization survey and bench- and pilot-scale chemical and biological treatability studies for Baker Performance Chemicals, Inc., in Dayton, Texas, to assess the treatment requirements for removal of conventional and toxic organics from wastewater generated during the production of specialty chemicals.

Oil Removal from Refinery Wastewater

Developed a preliminary design of a wastewater treatment system to treat petroleum-refining wastewaters for Peerless Oil and Chemicals, Inc. in Ponce, Puerto Rico. This study included an evaluation of the feasibility of treating refinery wastewaters in a biological treatment process that also treats contaminated groundwater from a defunct petrochemical complex adjacent to the refinery.

Cyanide Removal from Nitrobenzene Production Wastewater

Conducted a wastewater treatment feasibility study for the First Chemical Corporation, Pascagoula, MS that evaluated options for removing cyanide from plant effluent containing mononitrobenzene (MNB) steam stripper column overheads. The approach used to remove the cyanide from the MNB wastewater involved the application of polysulfide to the wastewater in CSTRs operating at temperatures approaching 80 degree C, converting the free cyanide in the MNB stripper overheads to thiocyanates. Bench-scale testing was used to confirm process chemistry. Flow, heat, and mass balance calculations were used to establish reagent dose and system operating conditions. The pretreated effluents from the cyanide conversion process were then commingled with other facility wastewaters and aerobically treated in the plant activated sludge process.

Locomotive Fueling and Washing Facility Wastewater Treatment

Conducted a wastewater treatment feasibility study for a Texas Roadhouse Facility of the Atchison, Topeka, and Santa Fe Railway Company (ATSF) which evaluated options for removing oils from waste streams generated during locomotive fueling and washing operations.

Olefins and Alcohol Production Wastewater Treatment

Developed a preliminary design for upgrade of the wastewater treatment facilities at the Vista Chemical Company, Lake Charles Chemical Complex. The facility produced olefins and alcohols from ethylene and other monomers. The upgrade included a combination of source treatments to reduce wastewater loads, segregation of high dissolved solids streams for separate discharge, stormwater segregation and treatment, pretreatment of waste streams for heavy metals removal, and the inclusion of an end-of-pipe aerobic continuous-culture tank-based activated sludge biological treatment system.

Refinery Activated Sludge Process Upgrade

Evaluated an existing wastewater treatment system for Marathon Petroleum Company at an integrated refinery in Texas. This study examined alternative wastewater treatment system upgrades to improve process performance for meeting effluent limitations. The recommended additions to the wastewater treatment system included equalization, new secondary clarifiers, and a tertiary filtration process.

Chlorinated Aliphatic Compound Removal from Wastewater

Performed in-plant wastewater characterization, and bench- and pilot-scale treatability studies for the Army Corps of Engineers to assess the treatment requirements for removal of toxic organics from wastewaters generated during the stripping and painting of military aircraft. The study resulted in the design and installation of wash water treatment facilities that included oil sorption, air stripping and activated carbon adsorption systems.

Treatment of Semiconductor Production Wastewater

Performed an in-plant wastewater characterization and treatment evaluation study of wastes generated from semiconductor manufacture that quantified major wastewater sources and recommended pertinent wastewater source reductions that anticipated changing operating conditions.

Treatment of Herbicide Production Wastewater

Performed a wastewater process evaluation of alternative methods for herbicide removal from treated wastewater effluents for the Monsanto Company. The evaluation focused on tertiary wastewater treatment technologies following aerobic activated sludge treatment. The secondary effluent treatment methods evaluated included chemical oxidation, activated carbon adsorption, and acid and alkali hydrolysis.

PROJECT EXPERIENCE – EXPLOSIVES-CONTAMINATED WASTEWATERS

AOP Treatment of Explorives-Contaminated Wastewater

Performed process engineering design studies with two types of advanced oxidation processes (AOPs) for the treatment of explosives-contaminated wastewaters from the Naval Air Weapons Station at China Lake, California. The project involved the examination of the sequential use of ultraviolet light and hydrogen peroxide treatment followed by an ozone-hydrogen peroxide process to achieve removal of TNT, TNB, HMX, and RDX in the presence of ketones, alcohols, and chlorinated aromatics in the China Lake facility wastewaters. Performed bench-scale treatability testing on facility wastewaters to establish system design parameters, developed the conceptual process design; flow, heat, and material balances through process; PFDs and P&IDs; major equipment specifications; and other supporting information for a 30% engineering design package.

PROJECT EXPERIENCE – HAZARDOUS WASTE MINIMIZATION

Minimization of Wastes from Metal Finishing Operations

Performed a waste minimization evaluation for the pre-clean and metal finishing facilities at the NASA Johnson Space Center, Houston, TX. The study reviewed waste management practices at the facility and identified waste minimization alternatives for modifying the existing waste management practices. The recommended waste minimization strategies included such treatments as evaporation, ion exchange, and microfiltration. The strategies were designed to increase water reuse and reduce hazardous waste production at the metal finishing facility. A preliminary design and budgetary cost estimate was developed for each of the candidate alternatives and the most cost-effective option was selected for further evaluation.

Catalyst and Desiccant Removal from Chemical Plant Process Vessels

Managed the removal of 417 tons of catalyst and desiccant materials from 22 reaction vessels from hydrocarbon and olefin production at a petrochemical complex in southeast Texas. The Hydrocarbons Plant had 206 tons of catalysts and 17 tons of desiccants for a total of 223 tons within 10 reaction vessels, and the Olefins Plant had 60 tons of catalysts and 134 tons of desiccants for a total of 194 tons within 12 reaction vessels. Approximately 32% of the materials were pyrophoric or mildly pyrophoric, largely dependent on the condition of the material at the time of reactor or adsorber shutdown. There was the potential for recovery of metals from approximately 20% of the catalyst materials from the reaction vessels. The project required the development of a sequence of activities that balanced the need to perform the catalyst and desiccant removal activities in a safe and effective manner, while also prioritizing ACM abatement, pyrophoric material handling and disposal, metals reclamation where practicable, and waste disposal. The activity involved the assembly of information on catalyst and desiccant type, quantity of material, physical characteristics, metals content, and condition at the time of reaction vessel shutdown, pollutant constituents associated with the materials, and the identification of potential recovery and acceptable handling practices and treatments. Other project activities included the development of catalyst and desiccant decontamination and unloading practices for each reactor/adsorber vessel.

Review of Product-Processes to determine Uranium and Thorium Use

Performed an investigation of the commercial production processes used in the manufacture of chemicals produced at a former chemical manufacturing facility between the 1940s and late 1970s. The study was undertaken to determine the chemical components and catalysts used in the generation of the primary chemical products and by-products. The product-processes and derivative processes included chemical groups within the classes' carboxylic acids and their associated salts, aldehydes, ketones, chlorinated aldehydes, chlorinated carboxylic acids, herbicides, insecticides, and chlorinated aliphatics. The site also produced muriatic acid as a by-product of the chlorination processes. The focus of the study was those product-processes that use catalyst types that employ uranium and/or thorium either in the production of the primary product or derivative products and the common waste streams generated and waste disposal practices prevalent in the historical time frame. The review of the products and their production processes indicated that thorium use was not likely given that other metal-based catalysts could also be employed with the majority of the production processes at much lower cost and with fewer environmental hazards. The review of the patent literature from the 1920s through 1970s found references to metal oxide catalysts where thorium could have been used, but these catalyst types had poor selectivity and would probably not be considered cost effective for industrial processing.

PROJECT EXPERIENCE – HAZARDOUS WASTE AND GROUNDWATER RECLAMATION

In Situ Remedial Technology Budgetary Cost Comparisons

Performed an engineering design and cost evaluation of remedial options for in situ treatment of solvent residue consisting of cis-1, 2-DCE, vinyl chloride, 1, 2-dichlorobenzene, 1, 4-dichlorobenzene, chlorobenzene, and benzene. Two in situ treatment strategies were evaluated for site remediation. These were oxidation with controlled-release oxygen compounds and reductive dechlorination with controlled-release carbon/metal sources. These oxidative strategies focused on the use of a slow release source of oxygen and nutrients to the affected areas that would stimulate the indigenous microorganisms at the site to aerobically biodegrade the target COCs. Two oxygen-release reagent products, calcium oxide and magnesium peroxide reagents were mixed with nutrients to enhance microorganism growth in the subsurface. A strategy that employed the use of barriers that were created by the injection of oxygen-release reagent was proposed. The methodology used multiple barriers positioned at upgradient locations in the impacted area. The barrier strategy employed multiple injection points for the oxygen reagent. The reductive dechlorination strategies for the site remediation used either additives that were composed of an emulsion of esterified organic acids attached to glycerin or an emulsified oil and zero-valent iron (ZVI) reagent mixture. Both reductive strategies involved injection into the contaminated saturated zone along the site of a barrier upgradient of the contamination. In-situ chemical reduction (ISCR) technology using Geoprobe pressure activated injection of the reagent slurry along a targeted injection line was employed during the study. Sulfate could act as a competing electron acceptor, but the dosing level was set to account for the possible impact. Nevertheless, there remained uncertainty associated with the use of ZVI in a sulfate reducing environment. In addition, the relevant COCs (VC and c-DCE) were theoretically preferred electron acceptors from a thermodynamic standpoint, and would normally be expected to affect CVOC degradation with sulfate still present. A detailed cost estimate for the implementation of the reductive dechlorination strategy was developed with reagent costs provided by vendors.

Synthetic Resin Manufacturing Wastewater Treatment

Performed an evaluation of technologies for the treatment of hazardous wastewaters produced at the Georgia-Pacific Chemicals, Inc. Elk Grove, CA facility. The study examined state-of-the-art treatments for specialty chemicals manufacturing wastewaters that were considered hazardous under California regulations. The focus of the study was to select processes that reduce contaminant loads and upgrade the quality of impacted wastewater from synthetic resin manufacturing operations. Treatment processes were identified that would meet water quality and/or discharge requirements under either pretreatment or the pollutant discharge elimination practices currently recommended for the specialty chemicals industry. Of the technologies evaluated, steam stripping was selected as an option for further evaluation because it provided the most complete removal of the COCs at the concentrations believed present in the facility waste streams. A single steam stripping system with the appropriate systems for scale control, pH control, and/or sequesterant addition was considered capable of achieving the required discharge quality. Biological treatment also was considered as an option for further evaluation if used together with pretreatment systems such as either gas stripping or solvent extraction. Tertiary GAC technology also was required for effluent polishing with a biotreatment treatment option. To assess whether a biotreatment strategy was appropriate for improvement of the quality of process wastewaters from resin production, a bench-scale biological treatment screening study was recommended that included testing of numerous waste streams from the batch production processes at the chemical facility.

Ex-Situ Treatment Options for Selenium and Arsenic Removal from Groundwater

Performed an evaluation of pump-and-treat options for selenium and arsenic removal from groundwater for a copper ore mining and smelting operation in El Paso, TX. The project included process selection, engineering design calculations, and the development of flow and mass balances, Process Flow Diagrams, Piping and Instrumentation Diagrams, equipment specifications, and costs for a tank-based microbial reduction process that converts selenate to elemental selenium and precipitates heavy metals within the bioreactor. The selenium and Arsenic are removed from the groundwater with sludges produced in the process.

In-Situ Treatment with PRB Systems for Arsenic Removal from Groundwater

Performed an evaluation of Permeable Reactive Barrier (PRB) systems for arsenic removal from groundwater for a confidential refinery client. The project included process selection, engineering design calculations, and the development of flow and mass balances, Process Flow Diagrams, equipment specifications, and costs for PRB systems using zero valent iron (ZVI) with additives formulated of treatment material containing controlled-release organic carbon, a source of sulfate, and other additives designed for treatment of dissolved trace metals and metalloids.

Design of Biological Reduction Process for Removal of Selenate-Selenium from Groundwater

Developed the conceptual design of a microbial treatment where selenate-selenium is removed effectively from contaminated groundwater by a reductive process. Microbial reduction is used to convert selenate to selenite, and selenite to elemental selenium where the selenium is ultimately removed from the groundwater with sludges produced within the process. The unit operations and/or processes proposed for treatment of the extracted groundwater include extracted water equalization and storage, anaerobic fixed growth bioreactors for microbial reduction of the oxyanions of selenium, contactors for air oxidation of reduced forms of iron, and final effluent filtration. Within the treatment plant are facilities for final effluent retention (i.e., clearwell), backwash pumping and retention with associated solids collection, backwash decant pumping, and nutrient and chemical feed systems.

Ion Exchange Treatment for Removal of Perchlorates from Contaminated Groundwater

Performed an evaluation of ion exchange resins and process technology for the Burbank CA Program Office of Lockheed Martin. The study examined alternative approaches to removal of low concentrations of perchlorates from groundwaters in the presence of high background levels of nitrates and sulfates. The evaluation included the examination of state-of-the-art high selectivity ion exchange resins in addition to conventional weak and strong-base anion resins.

Thermophilic Treatment of RCRA Hazardous Wastes

Conducted a laboratory study for the Chevron Research and Technology Company using chemoheterotrophic thermophilic bacteria to achieve enhanced hydrocarbon degradation during slurry-phase treatment of oily waste sludges from petroleum refinery operations. Aerobic and anaerobic bacterial cultures were examined under thermophilic conditions to assess the effects of mode of metabolism on the potential for petroleum hydrocarbon degradation. Changes in the hydrocarbon molecular weight distribution, infrared spectra, and PAH concentrations during slurry-phase treatment were documented.

Creosote Sludge Remediation

Conducted laboratory slurry bioremediation studies with creosote-contaminated sludges and soils from a former wood-preserving facility. Sludge and soil characterizations and laboratory-scale slurry reactor studies were performed that examined polycyclic aromatic hydrocarbon biodegradation in the presence of growth stimulating nutrient additives.

Soil-Wash Concentrate Bioremediation

Conducted bench-scale slurry bioremediation studies with concentrates from a soil-washing process treating soils contaminated with polycyclic aromatic hydrocarbons from a coke-oven facility. The study examined the use of an airlift-loop reactor to achieve 40 wt % solids in a bioremediation process capable of treating PAHs on fine-grain soils.

Slurry Bioremediation of K and F Wastes

Conducted bench-scale slurry bioremediation studies with oily waste sludges from the Valero Refining Company, Corpus Christi, TX. The sludges were primarily K and F wastes produced during wastewater treatment operations at the refinery. The studies were performed with bioreactors operating at 16 wt % solids. The biodegradation of polycyclic aromatic hydrocarbons and petroleum aromatics in the presence of stable petroleum emulsions was examined. This study provided proof-of-concept data for the application of the Bio-Slurry Reaction Process (BSRP) to the treatment of RCRA hazardous wastes from petroleum refining operations. The Valero refinery proceeded with the implementation of a commercial-scale BSRP technology which is currently treating 2,500 tons per year of RCRA hazardous wastes to the Universal Treatment Standards (UTS) for listed and characteristically hazardous wastes.

Sheridan Site Trust Superfund Site Remediation

Developed a slurry bioremediation process for the degradation of waste constituents in styrene-based tarry sludges and contaminated soils. The study included a pilot-scale treatability test where volatile and semivolatile constituents were biodegraded using a semicontinuous treatment process. This slurry-phase biological treatment pilot study was performed for the Sheridan Site Trust at the Sheridan Disposal Services Site in Waller County, Texas, and was the first pilot-scale demonstration of the Bio-Slurry Reaction Process (BSRP). The process proved effective for the degradation of polycyclic aromatic hydrocarbons, phthalates, phenolics, ketones, volatile aromatic hydrocarbons, and the lower chlorinated congeners of PCBs.

Slurry Bioremediation of Refinery RCRA Wastes

Conducted a laboratory biodegradation study of waste sludges from a petroleum refinery hazardous waste storage facility. These sludges were contaminated with volatile and semi-volatile pollutants including PAHs. The study resulted in the development of a bioremediation process that used above-ground reactors operated with high concentrations of microorganisms. This process utilized acclimated microorganisms, cultured to effect bioemulsification and achieved the formation of stable emulsions of waste tars and oils in water thereby enhancing the rate of biodegradation of RCRA hazardous constituents resulting in more complete treatment of these constituents at significantly shorter hydraulic residence times than achieved with conventional land application methods.

Soluble Hydrocarbon Removal from Groundwater

Performed process evaluation of alternative methods for soluble hydrocarbon removal from contaminated groundwaters for Exxon Corporation to assess the applicability of activated carbon treatment for removal of low levels of priority pollutants in drinking waters.

Refinery Groundwater Remediation

Investigated groundwater remediation alternatives for Chevron U.S.A., Inc. at an integrated refinery in California. Processes evaluated at the pilot-scale included oxidation of ferrous iron to ferric iron, dissolved and induced air flotation for separable hydrocarbon removal, air stripping for BTEX removal, filtration and activated carbon adsorption and/or biological oxidation for dissolved hydrocarbon removal, either individually or as a sequence of unit operations. These studies were conducted to select the most cost-effective ex-situ P&T remedial system for treatment of the refinery contaminated groundwaters.

PROJECT EXPERIENCE – NPDES PERMITTING SUPPORT

NPDES Permit Evaluation For Texas Refinery

Completed a NPDES wastewater permit application for the Valero Petroleum Company's Houston, Texas Refinery. Assisted the refinery environmental staff in sampling wastewater and stormwater streams, updating process wastewater information, and evaluating the impact of the addition of a SO2 scrubber blowdown stream on the existing wastewater treatment facilities. Prepared the application to allow new process waste streams from planned facility upgrades to be discharged as those new processes were brought on-line.

Petroleum Refining Wastewater Treatment Evaluation

Performed an evaluation of existing and emerging control technology for the treatment of petroleum refinery wastewaters and sludges for the University of Tulsa. The study examined pollution control technology for process wastewaters, spent acids, spent caustics, and other liquid wastes generated by petroleum refining operations. The study also examined land treatment techniques for disposal of refinery-generated solid wastes and made specific recommendations regarding acceptable control technology in this industry. The information was used to support NPDES permitting strategies for future petroleum refinery and petrochemical facility expansions.

Stormwater Runoff Modeling

Miscellaneous projects include a study of the technological impacts of Public Law 92-500 upon projected industrial water demand in Texas. Developed a methodology for estimating future industrial water demand, which incorporated this impact. Also developed methodology for estimating the magnitude of nonpoint source stormwater runoff from a watershed and applied the methodology to the nonpoint source analysis for the Alamo Area Council of Governments (AACOG) Area-wide Waste Treatment Management Plan.

PROJECT EXPERIENCE – ENVIRONMENTAL CONTROL SYSTEMS DESIGN

Review of Stormwater Improvements – Houston Airport System

Performed third-party review for the design of stormwater improvements at the Fuel Farm of the George Bush Intercontinental Airport Houston, TX (IAH). The project included the review of design drawings and specifications; the Basis-of-Design Report that outlined the project scope and the stormwater design calculations that referenced information obtained from technical papers, the Rainfall Frequency Atlas of the United States and the City of Houston Department of Public Works & Engineering for Stormwater Design Requirements. Reviewed the 30%, 60%, and 95% design submittals with the associated specifications.

SPCC Containment Strategy Methods and Practices

Conducted a Short Course for the technical staff of Austin Energy, City of Austin on containment strategies that are appropriate to electrical substations to contain and control oil spills compliant with Federal and State SPCC regulations. Reviewed exiting containment strategies at the Austin Energy electrical substations to determine their applicability to new substations throughout the City of Austin. Discussed standard and non-standard containment strategies and made recommendations on methods and practices for use at all Austin Energy electrical substations.

Containment Systems Design for Electrical Substations

Reviewed oil sensing technologies and containment systems to provide a recommendation for secondary containment design at the Austin Energy Brackenridge and Salem Walk electrical substations. Recommended containment strategies that emphasized low maintenance, minimum standing water around electrical equipment, limited stormwater quantity and standing water for long periods within the containment area, and minimum area to be cleaned after a spill. Technical memoranda were prepared that described the screening criteria and provided the design basis for the preferred containment system. The project included conceptual and detailed containment system designs with supporting process descriptions and specifications. Specifications were prepared to City of Austin bidding standards for the construction of infrastructure improvements.

USAID Environmental Impact Study

Conducted an Environmental Assessment (EA) for the U.S. Agency of International Development (USAID) and the World Bank in support of the development of off-site infrastructure for the Gaza Industrial Estate (GIE) in the Gaza Strip. The EA examined the impact of the GIE on the shallow freshwater aquifer that is vulnerable to declining water levels, salt water intrusion, and contamination from agricultural and other industrial activity. The EA included an assessment of industrial wastewater treatment, stormwater management, and solid waste disposal.

Heavy Metal Contaminant Fate and Transport

Conducted a preliminary site characterization for a confidential client using existing information for the nature and extent of mercury contamination in surface water, biota, and sediments of the Lavaca and Upper Matagorda Bays, Texas. The study identified the extent of mercury contamination within the Matagorda Bay System using available sample data and qualitative information on locations and levels of contamination within the impacted area. A contaminant fate and transport model was developed from existing data sources to estimate the likely impacts of future migrations of mercury and other heavy metals in the Matagorda Bay System.

Toxicity Reduction Evaluation

Conducted a wastewater treatment system Toxicity Reduction Evaluation (TRE) at a railroad tie plant facility for the Atchison, Topeka, and Santa Fe Railway Company (ATSF). The study was primarily concerned with establishing a conventional pollutant basis for evaluating the performance of the existing WWTP associated with the acute toxicity of Daphnia pulex and Pimephales promelas.

Fate and Transport of Alkylphenols in the Environment

Managed an environmental monitoring program for the Chemical Manufacturers Association that examined the presence of alkylphenol ethoxylates in a representative sampling of river reaches in the continental United States. The study was conducted to acquire information on the presence of alkylphenols in river sediments and surface waters downstream of municipal sewage treatment plant discharges from selected cities and towns in the United States.

Urban Stormwater Runoff Assessment

Managed nonpoint source data collection for the Lake Austin Study (NURP). Selected the stormwater runoff sampling sites and supervised the baseline evaluation that characterized each survey area. Developed the sampling procedures used in the collection of nonpoint source data and provided the technical support needed to evaluate the data obtained from each of the test watersheds.

Mercury Contamination Fate and Transport

Developed a comprehensive mercury pollution survey of the water, sediments, and biota of the Straits of Maracaibo, Lake Maracaibo, Venezuela. The study conducted in cooperation with Petroquimica de Venezuela (PEQUIVEN) was designed to assess the environmental impact associated with mercury pollution in the vicinity of the El Tablazo Petrochemical Complex near Maracaibo City. The study helped to establish an exposure profile for mercury pollution in the Straits of Maracaibo.

PROJECT EXPERIENCE – MUNICIPAL WATER AND WASTEWATER TREATMENT

Design of Iron and Manganese Removal System
Bexar County, Texas, USA

Performed the process design of iron and manganese removal from groundwater for the Bexar Metropolitan Water District (BMWD) Staggs Ranch development. The groundwater treatment plant employed pre-oxidation, coagulation, and vertical pressure filter (VPF) systems for solids removal. The design used conventional pressure filtration vessels with dual media (i.e., sand and anthracite) filtration beds. The hydraulic application rates were less than 5 gpm/sq. ft. to provide effective solids storage capacity with conventional filter-bed void volumes. The filters were sized for 10-ft diameter vertical pressure filter systems. Twelve vessels were used with 10 filters in service most of the time to achieve the 5 MGD water production level required by BMWD. The filter units were ANSI/NSF Standard 60 and 61 compliant. The reclaim water tanks were designed for sequence batch (i.e., two tank) operation. Ultrafiltration units were used to treat settled recycled filter backwash prior to blending reclaimed water with the raw influent groundwater at the headwork of the treatment system. The design included thickening and dewatering of chemical sludges prior to contract disposal.

Reverse Osmosis System Upgrade
Webb County, Texas, USA

Performed a design upgrade of an existing reverse osmosis (RO) groundwater treatment system for Webb County, TX. The project assessed the performance of treatment technologies in place at the water treatment facility. Existing unit operations included multi-media pressure filters, 5-micron cartridge filters, and the RO units. A new process schematic for the RO Facility was developed. This system modification included many of the components of the original water treatment facility. The proposed major additions to the modified water treatment system included new RO membrane treatment equipment; forced draft media fill aerators; facilities for membrane clean-in-place operations; and a new filtered water storage tank. Chemical feed systems for the addition of potassium permanganate, polymer, and RO membrane anti-scalant reagents also were provided as additions to the existing water treatment system. The new system required multi-media pressure filter pumps, RO system feed pumps, and an effluent lift station with associated pumps for transfer of treated product water to the existing ground storage tank. All pumps were sized to have 100% standby capacity and were designed to operate continuously. The expansion of the RO Facility included two new membrane treatment systems that provide adequate permeate and meet the required daily service volume of drinking water.

Wastewater Treatment Plant Improvements for Total Nitrogen Removal

Performed a design evaluation for Southwest Water Company (SWWC), Austin, TX to determine if equipment at their Cherokee Shores sewage treatment plant (STP) was adequate to meet the necessary mixing and aeration requirements for enhanced nutrient removal. The STP was experiencing difficulty in meeting the effluent discharge requirement for total nitrogen as well as experiencing elevated concentrations of TSS in the treated effluent. The project included the design of an upgrade to the nitrification-denitrification process. The modification included a pre-denitrification stage that required a high volume internal (nitrified mixed liquor) recycle and a first stage anoxic denitrification zone. Design packages were prepared for vertical shaft mixers with motors coupled to the propeller via a gear box for mixing the anoxic zone and submersible pumps for transfer of a high volume nitrified MLSS recycle. Determined the mixing and pumping requirements associated with the vertical shaft mixers and the submersible centrifugal nitrified mixed liquor recycle pumps. The impeller design for the recycle pumps was selected for pumping MLSS and also for passing particles/debris typical of sewage (e.g., rags, sticks, and similar items). The design also employed an anoxic mix chamber at the beginning of the process that separated 20-percent of the first basin from the main volume of the anoxic stage.

Design Review of Water Treatment Plant

Provided third-party review for the City of Austin (COA) of engineering plans and specifications for the implementation of Water Treatment Plant No. 4 (WTP-4) that will be located on Lake Travis, TX. The purpose of the reviews was to meet the environmental goals set by the Austin City Council for the four phases of the project (i.e., planning/preliminary design, design, construction and start-up). Reviewed technical memoranda, design drawings, and specifications for the WTP-4 design and participated in meetings to resolve technical differences. Principal role was to identify and recommend engineering design and construction practices that are protective of nearby environmental resources, sensitive species and their habitats. Familiarity with COA staff and operations expedited the technical memoranda and design drawing comment development and review. Provided the COA with the expertise that allowed integration of concepts, systems, and equipment of past successful projects into WTP 4 planning. The review process provided for a more environmentally friendly and energy conscious water treatment system design.

Design of Chloramine Disinfection System

Performed the process design of several Liquid Ammonium Sulfate (LAS) feed systems for chloramine disinfection at water treatment facilities owned by the Bexar County Metropolitan Water District (Bexar Met), San Antonio, TX. The process designs focused on disinfection of drinking water and corrosion control within groundwater storage tanks. Five of six Bexar Met projects focused on the design of LAS feed systems, while the sixth project included the design of chemical treatment with resin adsorption systems for arsenic, iron, and manganese removal from drinking water. These projects included process selection, engineering design calculations, and the development of flow and mass balances, process flow diagrams, piping and instrumentation diagrams, equipment specifications, and costs.

Biological Nutrient Removal with Carrousel Process

Performed a design review of the Al Kharj Road Sewage Treatment Plant for the Riyadh Water & Sewage Authority, Kingdom of Saudi Arabia. The project involved the review of process calculations, design drawings, and vendor equipment submittals for a 100,000 cubic meter per day (26.4 MGD) carrousel-type biological nutrient removal (BNR) activated sludge plant. The review resulted in recommendations for design improvements to achieve enhanced biological nitrification and denitrification and the control of filamentous microorganisms.

Wastewater Treatment Process Design Reviews

Performed design reviews of several sewage treatment plants for the Riyadh Water & Sewage Authority, Kingdom of Saudi Arabia. The project involved the review of process calculations, design drawings, and vendor equipment submittals for two identical sequenced batch reactor activated sludge plants, an oxidation ditch biological treatment process, and a biological denitrification tertiary sand filter. Recommendations included alternative diffused aeration system equipment and positive displacement sludge pumps and associated appurtenances.

Disinfection Contact Time Study

Conducted an assessment of the disinfection strategy at the City of Point Comfort, TX Water Treatment Facility and the impact of their strategy on Texas Commission of Environmental Quality (TCEQ) disinfection requirements for the Disinfectant Contact Time (CT) value. The project was performed for the Lavaca-Navidad River Authority (LNRA) who operates the plant. The LNRA strategy for disinfection by-product (DBP) control employed both chlorine dioxide and chloramines for disinfection. LNRA had previously used free chlorine for disinfection. The study determined whether acceptable CT values could be obtained with this disinfection strategy. A second element of the study was to make recommendations to LNRA for improved water treatment plant operation so that more consistent compliance with DBP rules could be achieved in the future. The study included a review of existing operating records, facility design drawings, and previous reports from other consultants. Using available data for the Point Comfort Water Treatment Plant, engineering calculations were made to determine CT values and whether they were compliant with both TCEQ standards and EPA's Enhanced Surface Water Treatment Rule (ESWTR). The study also evaluated options for improving the CT values to assure compliance with the ESWTR and other relevant rules.

NOM Removal from Drinking Water

Performed an engineering evaluation to remove Natural Organic Matter (NOM) and other trihalomethane precursors from drinking water produced at water treatment facilities located at the Naval Air Facility, El Centro, California. The project involved examination of dissolved organic carbon removal technologies for improvement of drinking water quality. The treatment technologies evaluated included Magnetic Ion Exchange (MIEX®) DOC resins, nanofiltration, chloramine disinfection, activated carbon adsorption, and enhanced coagulation.

Perchlorate Removal from Drinking Water

Performed an engineering evaluation of treatment technologies for removal of perchlorate from drinking water for Lockheed Martin. Biological, physical, and chemical treatment processes were examined, with ion exchange being the candidate technology selected for subsequent engineering and economic evaluations. Both strong-base anion exchange resins and a new class of bifunctional anion exchange resins were selected for more detailed pilot-scale testing with the contaminated drinking water source.

PROFESSIONAL AFFILIATIONS

American Society of Civil Engineers (Environmental Engineering Division)

Water Environment Federation

American Water Works Association

Associate Member of Sigma Xi, The Scientific Research Society

Tau Beta Pi, Chi Epsilon and Phi Kappa Phi Honor Societies

Order of the Engineer

Reviewer for the Journal of Industrial and Engineering Chemistry Research published by the American Chemical Society

Reviewer for the Journal of Environmental Science & Technology published by the American Chemical Society

Reviewer for the Journal of Hazardous Materials published by Elsevier

PUBLICATIONS

Other

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Castaldi, F. J., "Method and System for Removal of Selenium from FGD Scrubber Purge Water", U.S. Patent Number 6,235,204 B1, May 22, 2001.

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